

Simple and efficient water treatment and organic compound recovery of a biomass pyrolysis waste stream using vapor permeation membranes

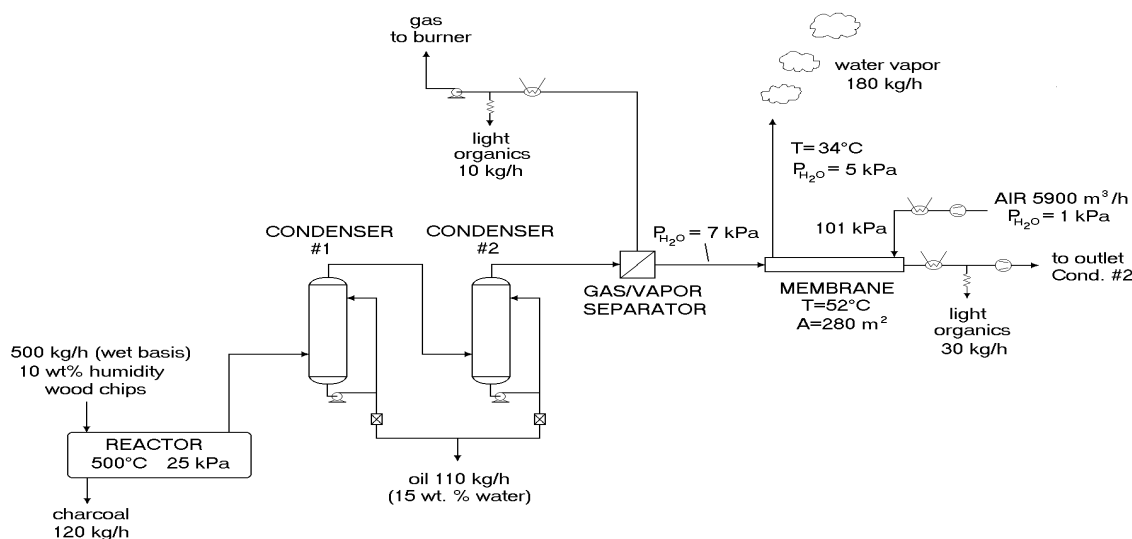
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A membrane vapor separation module was developed for continuous on-line separation of a biomass pyrolysis waste stream. The projected process flow diagram is shown as below. The membrane module consisted of solvent resistant polyimide membranes which were developed for this particular application. In the vacuum pyrolysis process, the waste water stream is generated with about 30,000 ppm TOC corresponding to 5.8% organic matters content as a vapor phase and is directly treated in the vapor phase. A saturated vapor stream at 38 °C is superheated to 52 °C and fed to the membrane module. Water preferentially permeates the membranes and is swept with an air stream and out through a chimney stack. The light organic organic compounds soluble in water are retained by the membrane and exit the membrane module as a concentrated vapor which is then condensed. The heavy organic fraction is in the outlet of the first condenser. This light organic fraction has potential commercial value. For vacuum pyrolysis of softwood bark residue, some compounds of interest identified in this organic fraction based on their market values were acetic acid, hydroxy propanone, furfural, guaiacol and 2-methyl-2-cyclopentenone. The separation of targeted compounds are currently under study in the authors' laboratories. In addition to vapor phase membrane treatment, other treatment methods were studied such as biological treatment, oxidation (KMnO_4 and ozone), reverse-osmosis, adsorption on activated carbon and distillation.



A detail quantitative analysis of the condensed waste aqueous phase stream which is representative of the feed to the membrane module showed the following compounds: methanol 3.4%, acetone 1.4%, methylacetate 0.5%, propanol 0.5%, butanedione 0.7%, formic acid 6.8%, acetic acid 25.6%, hydroxypropanone 5.1%, 2-methylfuran 0.5%, 3-ethoxypropanone 0.7%, propanoic acid 1.2%,

methylpropionate, 1.0%, cyclopentanone 1%, hydroxybutanone 1.4%, furfural 12.4%, ethylacetate 1%, propoxyethanol 1.2%, dimethylfuran 10.6%, cyclopentendione 0.3%, acetyloxy-2-propanone 0.3%, 2-methyl-2-cyclopentenone 1.5%, 2-furanylethanone 0.7%, methylfurfural 0.2%, furanone 0.7%, cyclohexenone 0.3%, hydroxycyclopentenone 0.1%, dimethylcyclopentenone 0.4%, benzaldehyde 0.3%, phenol 3.4%, hydroxymethylcyclopentenone 0.3%, dimethylcyclopentenone 0.2%, hydroxybenzaldehyde 0.3%, methylphenol 10.2%, acetophenone 0.7%, dimethylphenol 0.7%, ethylphenol 0.2%, methoxymethylphenol 1.9%, methoxyethylphenol 0.3%, eugenol 0.2% and levoglucosan 1%.

Bench scale tests were conducted with different feed configurations to the membrane module. In some cases, the permeate vapor was condensed rather than being swept with an air stream. The treated water vapor after condensation had 100 ppm TOC content. Formic and acetic acids were only compounds detected by GC/MS analysis. In separate experiments, the membrane used for this work was characterized with feed mixtures of acetic acid and water. The ratio of the permeability of water to acetic acid was determined to be 300. It is assumed that formic acid will have a similar permeability similar to acetic acid. The formic and acetic acids would account for about 25 ppm C in the water sample. The source of the other 75 ppm C has not been investigated at this stage.